Modic changes

Modic changes (MC) and endplate abnormalities (EA) have been shown to impact preoperative symptoms and outcomes following spinal surgery. However, little is known about how these phenotypes impact Cervical spine alignment.

Modic changes (MCs) are signal intensity changes of vertebral bone marrow adjacent to the endplates of degenerated intervertebral discs on magnetic resonance images (MRI) [1].

Modic changes are suggestive of being associated with low back pain (LBP). Data on determinants of MC and their association with disc degeneration and other spinal phenotypes, as well as that of LBP, rely mostly on small-scale patient populations and remain controversial.

Disc degeneration can be expected if Modic changes appeared but not vice versa.

Epidemiology

The prevalence of MC among patients with DDD of the lumbar spine varies between 19% and 59%. MC of types 1 and 2 are more common than those of type 3 and mixed changes.

Types

Reactive vertebral body modifications associated with disc inflammation and degenerative disc disease, as seen on MR images.

Type 1 refers to decreased signal intensity on T1-weighted spin-echo images and increased signal intensity on T2-weighted images, indicating bone marrow edema associated with acute or subacute inflammatory changes. Types 2 and 3 indicate chronic changes.

Type 2 refers to increased signal intensity on T1-weighted images and isointense or increased signal intensity on T2-weighted images, indicating replacement of normal bone marrow by fat.

Type 3 refers to decreased signal intensity on both T1 and T2-weighted images, indicating reactive osteosclerosis.

Modic et al. summarized the changes occurring in DDD and classified them into three types. Thereafter, the medical term Modic changes (MC) has appeared in various studies on spinal degenerative diseases.

see Modic type I changes

see Modic type II changes

see Modic type III changes.

Exact nature and pathogenetic significane largely unknown

Vertebral endplate and marrow changes [2].

Etiology

MC are considered a magnetic resonance imaging (MRI) parameter determining morphological changes in spinal degenerative diseases. Nonetheless, the etiology of MC remains poorly understood [3].

Current research suggests that an infective component may be involved that may identify novel potential treatments in patients with chronic low back pain refractory to other treatment modalities.

MC are thought to occur because of environmental, genetic, hormonal, mechanical, and degenerative factors, as well as because of the interaction of several unknown factors. Among the environmental factors, dietary habits and trends of DDD patients are considered one of the main ones. However, their significance in the monitoring and treatment of the disease remains unclear.

Histology

Modic 1 biopsies had evidence of highest bone turnover, possibly due to an inflammatory process; Modic 2 biopsies were consistent with a reduced bone formation/remodelling stage; Modic 3 biopsies suggested a more stable sclerotic phase, with significantly increased bone volume fraction (BV/TV), trabecular thickness (Tb.Th).Th compared to Modic 1 and 2, linked to increased bone formation and reduced resorption [4].

The resected intervertebral disc (IVD) tissue displayed moderate to severe degeneration, but there is no correlation between MR and histological grades using a qualitative classification system. There remains a need for a quantitative, non-invasive, pre-clinical measure of IVD degeneration that correlates with histological changes seen in the IVD [5].

Pathogenesis

There is usually a time sequence for Modic changes to convert from type 1 to type 3.

Like endplate, the fissures and clefts may also occur within the disc, particularly in the nucleus, and nerves and blood vessels increase with the severity of disc degenerate.

MC is generally progressive in middle age and furthermore is heritable. Since MC is associated with disc degeneration, which is also heritable, further work on potential shared mechanisms is needed [6].

Relationship between diet and Modic types

Few studies have examined the relationship between diet and Modic changes. Johansen et al. studied the relationship between vitamin D and MC and surprisingly found that MC were more common in individuals with normal levels of vitamin D than in those with low levels. However, the mechanisms underlying the development of MC remain unclear at present. Findings suggest that the link between vitamin D and MC is perhaps related to inflammation, though further confirmatory studies are needed

[7].

Individuals with MC are expected to have low levels of vitamin D because of an increased susceptibility to inflammation and/or because microfractures occur in the vertebrae because of increased levels of parathyroid hormone [8] [9].

Symptoms

Modic I and II area changes rate of of patients with low back pain is closely related to the degree of pain low back pain, Modic III area changes rate is not significant correlated to the degree of lower back pain [10].

Diagnosis

MRI is the imaging modality of choice for the assessment of degenerative changes in intervertebral discs. MRI has superior soft tissue contrast resolution when compared to other imaging modalities (eg, plain radiography, CT). An understanding of normal anatomy and MR appearances of intervertebral discs, particularly with regards to how these appearances change with advancing age, is required to aid image interpretation. Knowledge of the spectrum of degenerative processes that may occur in the intervertebral discs is required in order to identify and explain abnormal MRI appearances. As the communication of MRI findings may guide therapeutic decision making and surgical intervention, the terminology used by radiologists must be accurate and consistent [11].

Treatment

There is controversy regarding whether the spinal fusion will provide better and more durable outcome than discectomy [12].

VESC prevalence increases with age, underlying the degenerative causative etiology. Surgical indication shouldn't be stated on the basis of the VESC findings alone, the main factor for indicating surgery depends more on other associated degenerative spinal changes [13].

Vertebroplasty with bioactive resorbable bone cement seems to be an effective therapeutic option for patients with low back pain resistant to conservative treatment whose origin could be recognized in Modic type I end plate degenerative changes [14].

Outcome

The presence of Modic changes may be a risk factor contributing to the unfavorable outcomes after discectomy for lumbar disc herniation, because disc excision often could not sufficiently relieve the low back pain caused by vertebral endplate changes. Accordingly, spinal fusion has been considered by some surgeons for the treatment of patients with lumbar disc herniation, chronic low back pain, and Modic changes.

Patients with MRI confirmed symptomatic lumbar disc herniations and MC report significantly lower levels of pain reduction after a lumbar nerve root block compared to patients without MC [15].

Patients with lumbar radicular pain have a substantial pain reduction during 1-year follow-up, but Modic type I changes may imply a slower initial decrease in sensory pain [16].

Case series

2015

2,449 Southern Chinese volunteers.

Sagittal T2 weighted image in the MRIs of the lumbar spine were assessed for the presence of MC and other spinal phenotypes (eg, disc degeneration, disc displacement, Schmorl nodes) in all individuals. Subjects' demographics, occupation, lifestyle, and clinical profiles were assessed.

The overall prevalence of MC was 5.8% (n=141), which increased with advancing age. Modic changes predominantly occurred at the lowest two lumbar levels (83%). In the multivariate analyses, only the presence of disc displacement and a higher disc degeneration score were associated with MC at the upper lumbar levels (L1/L2-L3/L4) ($p<.01$). The presence of MC at the lowest two lumbar levels (L4/L5-L5/S1) were associated with age, the presence of Schmorl nodes, disc degeneration or displacement, and historical lumbar injury ($p<.01$). Subjects who were both smokers and overweight or obese had increased likelihood of MC in the lower spine (OR: 2.18; 95% CI: 1.10-4.30). The presence of MC at the lower lumbar levels were associated with historical LBP (OR: 1.93; 95% CI: 1.05-3.54) and with severity and duration of symptoms ($p<.05$).

Based on one of the largest MRI studies to assess lumbar MC, Mok et al. noted that MC were associated with both disc degeneration and the presence and severity of LBP. Determinants and association of MC with disc degeneration and clinical symptoms in the upper versus the lower lumbar spine were different. The study further stresses the significance of MC as important imaging phenotypes associated with LBP [17].

1988

Modic et al., reviewed magnetic resonance (MR) images of 474 consecutive patients referred for lumbar spine MR imaging. Type 1 changes (decreased signal intensity on T1-weighted spin-echo images and increased signal intensity on T2-weighted images) were identified in 20 patients (4%) and type 2 (increased signal intensity on T1-weighted images and isointense or slightly increased signal intensity on T2-weighted images) in 77 patients (16%). In all cases there was evidence of associated degenerative disk disease at the level of involvement. Histopathologic sections in three cases of type 1 change demonstrated disruption and fissuring of the end plates and vascularized fibrous tissue, while in three cases of type 2 change they demonstrated yellow marrow replacement. In addition, 16 patients with end-plate changes documented with MR were studied longitudinally. Type 1 changes in five of six patients converted to a type 2 pattern in 14 months to 3 years. Type 2 changes in ten patients remained stable over a 2-3-year period. These signal intensity changes appear to reflect a spectrum of vertebral body marrow changes associated with degenerative disk disease [18].

1987

MR studies of the lumbar spine in 41 patients were analyzed at 203 disk interspaces to assess the appearance and frequency of bone marrow signal changes in the vertebral bodies adjacent to normal and degenerated disks. Degenerative changes were found at 58 interspaces; an abnormal bone marrow signal was identified in 29 (50%) of these. On spin-echo pulse sequences with short and long repetition times (TRs) and echo times (TEs), an area of relative increased signal intensity was seen in the vertebral body adjacent to the disk in 24 cases (17 were bandlike on both sides of the disk, four were focal on one side of the disk, and three were bandlike and focal on one or both sides of the disk). In one patient decreased signal was noted on both short and long TR/TE imaging. In the other four patients decreased signal was noted on short TR/TE pulse sequences and increased signal was evident on long TR/TE. These marrow changes were not present adjacent to normal disks. The relatively high signal intensity on both short and long TR/TE pulse sequences suggests that the increased signal resulted from the conversion of normal hemopoietic bone marrow to fatty marrow. We conclude that bandlike or focal areas of high signal intensity in the bone marrow adjacent to degenerated intervertebral disks occur commonly on MR images of the spine and must not be confused with signal changes from tumors or infections involving the disk space and adjacent vertebral end plates [19].

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